RADIOLOGICAL DOSE CALCULATIONS FOR THE ANNUAL ENVIRONMENTAL SURVEILLANCE REPORT

Purpose

This Meteorology and Air Quality Group (MAQ) procedure describes the process to perform dose calculations to be reported in annual environmental surveillance reports (ESRs), as required by DOE Orders 5400.1 and 5400.5 and implementation guidance DOE/EH-0173T. This procedure also includes methodology for dose calculations (beyond the DOE requirements) to provide supplemental information concerning nearby populations and other potentially affected parties.

Scope

This procedure applies to the calculation of doses, to be reported in the annual Environmental Surveillance Reports, from all significant pathways to hypothetical individuals identified as potentially receiving the largest doses and to the population within 80 km (50 miles) of the Laboratory. Other doses may be calculated for hypothetical individuals as part of special studies that may be short term or one-time evaluations.

In this Procedure

Hazard Control Plan

The hazard evaluation associated with this work is documented in HCP-MAQ-Office Work.

Signatures
(continued on next page)

Prepared by:	Date:
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06/06/02

General information about this procedure

Signatures *(continued)*

Approved by:	Date:
Terry Morgan, QA Officer	4/18/02

Attachments

This procedure has no attachments.

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description of Changes
0	5/6/02	New document.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- individual(s) responsible for calculating doses reported in ESR

Annual retraining is required and will be by “self-study” (reading) training.

Training method

The training method for this procedure is “**self-study**” (**reading**) and is documented in accordance with the procedure for training (MAQ-024).

Prerequisites

In addition to training to this procedure, the following training is also required prior to performing this procedure:

- advanced health physics, e.g., certification by the American Board of Health Physics or courses in radiation physics, dispersion modeling, biological effects of radiation, and public health
- dose modeling using GENII (familiarity can be gained through running the program, reading the user guides and other support materials, and/or working with someone familiar with the program)
- use of RESRAD (familiarity can be gained through running the program, reading the user guides and other support materials, and/or working with someone familiar with the program)
- use of Microsoft Access (level of training needs to be sufficient to allow retrieval of tables and queries and occasional development of new queries)

General information, continued

Definitions specific to this procedure

Direct dose: a general term to describe doses received from radiation sources external to the body such as a photon or neutron source. Potential sources include radioactive materials in air, radioactive materials on the ground or in buildings, accelerators, or criticality experiments.

Dose: A general term used to describe any radiological dose received. In general, this refers to the effective dose equivalent and may or may not be a committed dose depending on whether the radiation was internal or external.

Effective Dose Equivalent, EDE: The sum of the products of the dose equivalent to the organ or tissue and the weighting factor applicable to each of the irradiated body organs or tissues. This gives the "effective" dose to the whole body from an irradiation of some or all organs and tissues and carries the same risk to health as the organ and tissue doses.

GENII: A collection of computer codes developed to incorporate the internal dosimetry models recommended by the international commission on radiological protection (ICRP) into the environmental pathway analysis models used at Hanford. It may be used to model radiation doses received by individuals or populations from routine or accidental releases of radionuclides to air or water. Calculation of doses from residual contamination or spills is also possible.

Inhalation dose: The committed effective dose equivalent (see definition above) received from inhalation of radioactive material.

Ingestion dose: The committed effective dose equivalent (see definition above) received from eating or drinking radioactive material.

Location group: A group of stations or sampling sites that are grouped on the basis of some commonality to provide a set of data for comparison. For example, a group of sampling locations distant from the Lab can be grouped and averaged to provide a background value. These would likely be referred to as the "Off-site Regional" or simply as "Background" group.

Member of the public (we use the definition from DOE Order 5400.5): a person who is not occupationally associated with a LANL/DOE facility or operation.

General information, continued

Definitions continued

MEI (Maximally exposed individual): Individuals who are characterized as receiving the largest dose from the LANL facility from all pathways. We define an off-site MEI as a member of the public not on LANL or DOE property and an on-site MEI as a member of the public who received the majority of their hypothetical dose while on DOE/LANL property or on publicly accessible roads that that pass by LANL facilities.

Penetrating radiation: Penetrating radiation; which includes photon radiation and neutrons, is emitted by radioactive atoms (such as cobalt-60) or from manmade sources such as accelerators or criticality experiments, and from terrestrial and cosmogenic sources. When the source of the penetrating radiation is removed, there is no longer any exposure.

Penetrating radiation dose: The effective dose equivalent received from penetrating radiation.

RESRAD: A collection of computer codes developed for implementing the DOE's residual radioactive material guidelines. The program allows calculations of doses based on exposure to contamination in the soil, surface water, or ground water.

References

The following documents are referenced in this procedure:

- MAQ-024, "Personnel Training"
- MAQ-505, "Calculation of Direct Dose from TA-18"
- MAQ-506, "Calculation of Air Activation Activity from TA-18"
- 1996 Annual Environmental Surveillance Report
- USNRC Regulatory Guide 1.109, Revision 1, Oct. 1977
- EPA Exposure Factors Handbook, Konz et al, 1989
- DOE/EH-0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," DOE 1988

Note

Actions specified within this procedure, unless preceded with "should" or "may," are to be considered mandatory guidance (i.e., "shall").

Background

Dose calculation background information

DOE Order 5400.5 Chapter II Section 6b states "Doses to members of the public in the vicinity of DOE activities shall be evaluated and documented…" "Collective doses to the public within 80 km of the site shall also be evaluated and documented at least annually." Regarding doses calculated for hypothetical individuals, Chapter II Section 6b(3)(b) states "Doses calculated should be as realistic as practicable. Consequently, the individuals subject to the greatest exposure shall be identified, to the extent practicable, so that the highest dose might be determined." The Order also states (Chapter I Section 10) that dose calculations include routine and unplanned releases and that all significant exposure pathways be considered.

Calculations performed in accordance with this procedure include doses from all significant pathways to hypothetical individuals identified as potentially receiving the largest doses and to the population within 80 km (50 miles) of the Laboratory. Other doses may be calculated for hypothetical individuals as part of special studies that may be short term or one-time evaluations.

Identifying doses that require evaluation

Individuals can receive doses from several LANL sources via several pathways and various scenarios. The prime pathways are: air (inhalation, direct exposure, and ingestion of contaminants originally dispersed via the air); water and food (ingestion); direct exposure to photons and neutrons from experimental or other facilities; or direct exposure to direct penetrating radiation sources in contaminated ground or water. This MAQ procedure describes the calculation of:

- Dose to the exposed population within 80 km of the Lab
- Dose to the maximally exposed individual outside of Lab boundaries (referred to as the off-site MEI)
- Dose to the maximally exposed member of the public within Lab boundaries (referred to as the on-site MEI)
- Average doses to residents of Los Alamos and White Rock from all sources and pathways
- Doses from ingestion of foodstuffs and water at various locations in northern New Mexico
- Special scenario doses, including doses from exposure to contaminated material

Background, continued

Identifying location of on- and off-site MEIs

LANSCE and TA-18 have usually been the sources of greatest potential exposure to a member of the public. An extensive evaluation of the need for direct penetrating radiation monitoring completed late in 1999 revealed several other sites of potential public exposure. Follow-up sampling at these locations identified the Calibration Facility (TA-3-130) as an important source of exposure to the maximally exposed individual (MEI), though this facility has since closed. Wastes stored at Area G have also been identified as a potentially significant exposure source. The process for evaluating doses from these facilities is discussed below.

Each year, the dose calculator should review activities at TA-18, TA-54, LANSCE, and any other facilities with potentially significant exposure pathway to a member of the public, and the monitoring near these facilities to assess potential locations of maximum exposure for on- and off-site MEI scenarios. It may be necessary to perform preliminary calculations to determine the greatest exposure potential. Additionally, there should be regular evaluations to determine if new, increased, or reconfigured sources could change the exposure potential near these or other LANL facilities.

Calculating collective population dose within 80 km

Overview

This modeled dose is based on all sources and pathways from LANL. Stack sources and the air pathway are usually dominant; for these, you should use either the GENII or the CAP88 computer code.

This calculation involves four parts:

- Obtain stack source term
- Consider the Area G source term
- Perform GENII or CAP88 modeling
- Calculate total dose

Steps to obtain monitored stack annual air source terms

To obtain monitored stack annual source terms for air emissions, perform the following steps:

Step	Action
1	To obtain annual source terms for all monitored stacks (except TA-53) from the RADAIR emissions inventory database, run the query "ESR Annual All Stacks Except TA53". You will be prompted for the 4-digit year. Make a professional judgement as to which radionuclides to include, or refer to the Rad-NESHAP evaluation. In general, emissions reported for any of the following radionuclides should be considered: • Tritium (sum emissions from HTO and gas) • Cobalt-60 • Strontium-90 • Yttrium-90 • Uranium (all isotopes) • Plutonium (all isotopes) • Americium-241 • Thorium (all isotopes) **Note:** The data for the year of interest should be in the database and verified by the end of March of the following year. This query will provide all stack emissions (except TA-53, which is handled separately). Several of the radionuclides reported do not add significantly to the population dose but do add great complexity to the modeling because they are not in the GENII library and because, for many of them, no dose conversion information is available. That is why the person responsible for calculating dose must make the decision as to which to include.

Steps continued on next page.

Calculating collective population dose within 80 km, continued

Step	Action
2	To obtain annual source terms for LANSCE emissions from the RADAIR emissions inventory database, run the query "ESR Annual TA53". You will be prompted for the 4-digit year. Use professional judgement to decide which radionuclides to include. Most of the dose usually comes from ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar. A "standard" list for modeling includes: • Tritium (gas and HTO should be summed) • Carbon –10, -11 • Oxygen-14, -15 • Nitrogen-13, -16 • Argon-41. **Note:** The data for the year of interest should be in the database and verified by the end of March of the following year. This query will provide all TA-53 stack and diffuse emissions. Several of the radionuclides reported do not add significantly to the population dose but add complexity to the modeling because they are not in the GENII library and, because, for many of them, no dose conversion information is available.
3	Note which of the emissions are from a diffuse source and compile these separately from the stack emissions. This is necessary because the diffuse source modeling will require different meteorology in the GENII runs than the stack emissions.
4	If another individual is responsible for completing the calculation method in MAQ-506, retrieve the calculated ^{41}Ar source term. Otherwise, perform the ^{41}Ar source term calculation in MAQ-506. **Note:** Argon-41 is the only potentially significant contributor to population doses from TA-18 operations.

Calculating Area G annual air source terms

Estimate the Area G source terms by comparing with previous annual data. If the estimate exceeds 0.1 person-rem, perform the following steps, as needed:

Step	Action
1	Go into the directory used to run GENII. Make sure that Areag.in file is in the same directory as the DEFAULT.IN file.

Steps continued on next page.

Calculating collective population dose within 80 km, continued

Step	Action
2	Call up the FILENAME.DAT file under a suitable editor. On line 22, change DEFAULT.IN to AREAG.IN and re-save the FILENAME.DAT file under the same name. **Note:** The Areag.in file is needed to change the distances calculated for X/Q values to include the 100 m distance.
3	Perform a GENII run using the TA-54 population file and the TA-54 Met file from the current year. Perform a run for 1 Ci of ^{238}Pu only (no other radionuclides are needed). Use appropriate parameters and exposure scenarios according to professional judgement. The output file, which documents these choices, should be retained in the records.
4	After performing the GENII run, retrieve the chiq.in file that was created by the run. Open the file in Excel, "clean it up" so that all the data are in the correct columns, and save it as "AreaGXQ[current year].xls.
5	Go back into the FILENAME.DAT file and change "areag.in" back to "DEFAULT.IN."
6	Calculate χ/Q_{100}: Open the AreaGXQ[current year].xls file in Excel and average the χ/Q values provided for each of the 16 wind sectors (which should correspond to a 100 m distance).
7	Retrieve AIRNET data for all stations at Area G that were active throughout the entire year.
8	Calculate the average annual concentration for ^{3}H, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, and ^{241}Am in Ci m^{-3} **Note**: activity units need to be **Ci**, not aCi or pCi.
9	Calculate the annual emission rate (annual source term) for each radionuclide according to the following equation: $E_r = 3.1536 * 10^7 * \chi_a / (\chi/Q_{100})$ where: E_r = emissions rate for radionuclide r (Ci y^{-1}) χ_a = average annual air concentration for radionuclide a (Ci m^{-3}) χ/Q_{100} = the average χ/Q at 100 m from the source (s m^{-3}) (previously calculated) $3.1536 * 10^7$ = the number of seconds per year (converts emission rate from s^{-1} to y^{-1}). **Note:** The values calculated are then used as annual source terms in the GENII runs to calculate the population dose from Area G emissions.

Calculating collective population dose within 80 km, continued

Perform runs

Perform GENII or CAP88 runs. Consider the LANSCE stacks, non-LANSCE stacks, LANSCE diffuse sources, TA-18 ^{41}Ar source, and Area G diffuse source. If LANSCE has not been active that year, you may decide to do some preliminary runs to evaluate the dose potential from LANSCE operations. If the dose potential from LANSCE is negligible, then it is not necessary to perform all the runs from all LANSCE sources but the process should be documented.

General steps to perform GENII runs

To perform GENII runs, perform the following steps:

Step	Action
1	Input the source terms (radionuclides and quantities) for each significant release point along with appropriate data on stack height, stack diameter, and stack flow into GENII (see step 1 in the chapter *Off-site MEI dose*). **Note:** Stack parameters for all monitored stacks are listed in the annual emissions report "U.S. Department of Energy Report [current year] LANL Radionuclide Air Emissions."
2	Use the population file and meteorology data appropriate for the release point. **Note:** The population files for each major potential source are located in the GENII subdirectory of the ESR Dose Calculation directory under the Projects on Clean Air drive. Use the population file that corresponds to the source location. The population files are named by TA. These population files should be updated periodically by the Rad-NESHAP Project. Environmental Measurements Project personnel are responsible for reformatting these population files into GENII format and for replacing the old files with the new ones in the directory listed above. This updating process can be ensured if the person performing the annual ESR doses (by following this procedure) checks if the population files have been updated for that year. If they have been updated, you need to update the GENII subdirectory with the correctly formatted files (GENII compatible). Whether the updated files are in correct GENII format can be verified by comparing the new files with those in the active GENII subdirectory (before replacing them).

Steps continued on next page.

Calculating collective population dose within 80 km, continued

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>3</td><td>Download meteorology data from the MAQ meteorology web page:

http://weather.lanl.gov/cgi-bin/starfilerequest.pl

Remove the top few lines on the downloaded meteorology data file down to the line indicated in the note included at the top of the file. For modeling LANSCE stack and diffuse sources, use meteorology specific to the time of the accelerator run cycle. (This can be determined either by asking the LANSCE contact or by looking in the RADAIR database under the LANSCE EMISSIONS Table, which shows the start dates associated with each emission.) For non-LANSCE sources, use the meteorological data for the entire year.</td></tr>
<tr><td>4</td><td>Name the file with the appropriate year and tower, e.g. 98-TA54.met or 98-TA53.met, and move the file into the ESR/MET directory.

Note: The table below indicates which met tower data to use for each source.

<table>
<tr><th>Tower</th><th>Technical Areas included</th></tr>
<tr><td>TA-6</td><td>3, 6, 8, 9, 11, 14, 15, 16, 22, 28, 35, 40, 41, 43, 48, 50, 52, 55, 59, 60, 61, 63, 64, 69</td></tr>
<tr><td>TA-49</td><td>33, 36, 37, 39, 49</td></tr>
<tr><td>TA-53</td><td>2, 5, 21, 46, 51, 53</td></tr>
<tr><td>TA-54</td><td>18, 54</td></tr>
</table>
</td></tr>
</table>

Calculate total collective dose

Sum the collective doses calculated from the GENII or CAP88 runs to determine the total collective dose within 80 km.

Calculating off-site MEI dose

Overview

In the past, the primary dose contributor to the off-site MEI was the accelerator at LANSCE. Because emissions from LANSCE are short-lived photon emitters and are not measured effectively with the ambient air monitoring network (AIRNET), the dose from these sources is modeled using emissions data provided by LANSCE operations personnel. The air pathway dose from Lab operations other than LANSCE may be evaluated by using data from the AIRNET station at East Gate.

Location of MEI

Sources of direct radiation exposure within the Lab must be reviewed to determine if they are a likely source of dose that would make a nearby member of the public the maximally exposed individual. Sources of exposure that have been identified include LANSCE, TA-18, and the storage domes at TA-54.

LANSCE should be considered as a potentially significant exposure facility. But, if LANSCE has no significant operations during the subject year, East Gate will not be the location of the off-site MEI. If no single facility can be identified as the source of the maximum public dose, then review AIRNET data at locations of public exposure. When LANSCE or another single facility is not the obvious source of the largest potential dose, an initial screening using AIRNET data may be used to help identify the location of the MEI. Determine the site (as defined as a potential MEI location under 40 CFR 61) that would have the highest dose based on ambient, net concentrations of plutonium isotopes, americium, and tritium. Unless the uranium isotopic ratio (U234/U238) departs significantly from one, it is generally assumed that the airborne uranium is not of LANL origin and should therefore not be included in the dose calculation. To this dose calculated from AIRNET data, you should add the modeled doses from facilities whose emissions aren’t measured by AIRNET, and doses from other pathways as described below.

Calculating off-site MEI dose, continued

Modeling LANSCE contribution

To model the LANSCE contribution to the off-site MEI dose, perform the following steps:

Step	Action
1	Run the query ESR Period Emissions to retrieve the source terms for LANSCE stack and diffuse emissions from the RADAIR emissions inventory database. You will be prompted to enter the year for which data are needed. **Note:** Running this query will provide both stack and diffuse source terms. Stack sources will be associated with a Period (1-12) whereas diffuse sources will indicate Period 0.
2	Go to the LANSCE time table to evaluate what dates correspond to each period. **Note:** The dates for Period 0 include the entire operating cycle. The dates of each period must be known in order to retrieve the meteorological data that correspond to that time period.

Determine the location of the off-site MEI for LANSCE operations

If LANSCE is found to be a significant emissions source, then proceed with the following steps to identify the location of the MEI for LANSCE operations and to calculate the dose to that MEI.

The exact location of the MEI among several possible locations around East Gate is dependent on year-specific meteorology, so this step is necessary each year. Perform a run for each LANSCE source (from Step 1) for each receptor location. All exposure and run parameters should be kept the same except those that are related to individual stacks and location of the exposure point being modeled. In other words, you will change stack parameters such as release height, stack radius, and exhaust velocity and the location of the exposure, as needed.

Calculating off-site MEI dose, continued

Steps to determine the location of the off-site MEI

To determine the location of the off-site MEI, perform the following steps:

Step	Action
1	Obtain stack height, stack diameter, and exhaust velocity from Table 4 of the "U.S. Department of Energy Report [current year] LANL Radionuclide Air Emissions." GENII requires input of "Stack Flow" whereas the report only tabulates "Exit Velocity." Convert from "Exit Velocity" to "Stack Flow" using the following equation: $SF = (SD * 0.5)^2 * PI * EV$ where: SF = stack flow ($m^3\ s^{-1}$) SD = stack diameter (m) PI = 3.14159 EV = exit velocity ($m\ s^{-1}$)
2	Perform a run for each LANSCE source for each receptor location. Keep all exposure parameters identical; change only the stack and release parameters as appropriate and the location of the exposed individual. **Note:** The total number of runs will be three times the number of LANSCE sources. The three potential MEI locations relative to ES-7 are: **north sector — Sector #9 @ 975 m** **north-northeast sector — Sector #10 @ 944 m** **northeast sector — Sector #11 @ 1,120 m**
3	Identify the MEI by choosing the location with the largest calculated EDE. **Note:** The MEI location is dependent on year-specific meteorology and must be determined each year.

Calculating off-site MEI dose, continued

Perform GENII runs for dose from LANSCE sources

Perform the following steps to determine the dose contribution from LANSCE sources.

Step	Action
1	Perform a run for each LANSCE source for the identified MEI. Do a run for each source for each period using the meteorological data from the TA-53 tower for that period. The runs for each diffuse source should use meteorological data for the entire run period as defined for Period 0 in the LANSCE time table. Ensure that all significant dose contributors have been included. **Note:** It is normally necessary to include only ^{3}H, ^{41}Ar, ^{10}C, ^{11}C, ^{13}N, ^{16}N, ^{14}O, and ^{15}O. Other radionuclides contribute extremely small dose increments.
2	Sum the effective doses (rem) from all runs and multiply the summed effective dose by 1000 to calculate the effective dose in mrem from LANSCE operations.

Perform runs for TA-18 airborne emissions dose

Perform the following steps to determine the dose contribution from airborne emissions from TA-18.

Step	Action
1	If another individual is responsible for completing the calculation method in MAQ-506, retrieve the calculated ^{41}Ar source term. Otherwise, perform the ^{41}Ar source term calculation in MAQ-506. **Note:** The only potentially significant contributor to doses in Los Alamos and White Rock from TA-18 operations is ^{41}Ar.
2	Perform GENII or CAP88 runs to determine the air-pathway dose from ^{41}Ar to the MEI. If the MEI is at East Gate, the individual is 3000 m due north (sector 9) from TA-18.

Measured air pathway contribution from all sources

Perform the following steps to determine the dose contribution from ambient air from all sources.

Step	Action
1	Obtain the AIRNET quarterly isotopic results for the AIRNET stations closest to the MEI for the entire calendar year from the Access AIRNET database.
2	Calculate average annual air concentrations for ^{3}H, ^{234}U, ^{235}U, ^{238}U, ^{241}Am, ^{238}Pu, and ^{239}Pu.

Steps continued on next page.

Calculating off-site MEI dose, continued

Step	Action
3	Calculate the air-pathway inhalation dose from these radionuclides according to the following equation: $D_r = AC_r * DF_r * B * 8.76 * 10^{-6}$ Where: D_r = air inhalation dose in mrem from radionuclide r (mrem); AC_r = annual average air concentration of radionuclide r (aCi m^{-3}); DF_r = inhalation dose conversion factor for radionuclide r (rem μCi^{-1}) taken from "Internal Dose Conversion Factors for Calculation of Dose to the Public" (DOE/EH-0071, DOE 1988). **Use the most conservative (largest) inhalation dose conversion factor of those listed for each radionuclide;** B = breathing rate (m^3/h); B = 0.7 m^3/h is recommended; and $8.76 * 10^{-6}$ is a unit conversion factor (mrem μCi h y^{-1} aCi^{-1} rem^{-1}). **Example calculation:** DOE 1988 dose factor is 460 rem μCi^{-1} for ^{238}Pu Hypothetical annual ^{238}Pu average is 8.0 aCi m^{-3} Calculated dose from: ^{238}Pu = 8.0 aCi m^{-3} * 460 rem μCi^{-1} * 0.7 m^3 h^{-1} 8.76 * 10^{-6} mrem μCi h y^{-1} aCi^{-1} rem^{-1} = 0.023 mrem
4	Sum the inhalation dose from each radionuclide to calculate the total air-pathway inhalation dose from all radionuclides. **Note:** These calculations provide the 50-y committed effective dose equivalent. The dose is reported as if it occurs entirely during the first year.

Ingestion doses from food products and well water

Perform the following steps, as appropriate, to determine the dose contribution from food ingestion and from water consumption.

Step	Action
1	Perform the food ingestion dose calculations described below (in the chapter *Calculating Dose from Ingestion*) and sum the doses for each food product reported for Los Alamos and White Rock. This is the total food ingestion dose.

Steps continued on next page.

Calculating off-site MEI dose, continued

Step	Action
2	Obtain tap water sampling results, as appropriate, and include the original data in the records file. Convert units to pCi/L if necessary.
3	If tap water results (other than uranium isotopes) for Los Alamos and White Rock are above regional values, calculate the incremental dose attributable to LANL according to the equation below. If results are statistically indistinguishable or lower than regional values, then no LANL dose needs to be calculated. Calculate the 50-y annual dose commitment according to the following equation: $$D_r = WC_r * DF_r * 0.73$$ Where: D_r = water ingestion dose in mrem from radionuclide, r (mrem). WC_r = concentration in water of radionuclide, r above regional concentration (pCi L^{-1}) DF_r = ingestion dose conversion factor for radionuclide, r (rem μCi^{-1}) taken from "Internal Dose Conversion Factors for Calculation of Dose to the Public" (DOE/EH-0071, DOE 1988). Use the most conservative (largest) ingestion dose conversion factor of those listed for each radionuclide. 0.73 = a unit conversion factor (mrem μCi L rem^{-1} pCi^{-1}) that incorporates an annual water ingestion rate of 730 liters, considered an upper-normal ingestion rate (Exposure Factors Handbook, Konz et al, 1989). **Example calculation:** DOE 1988 dose factor is 0.13 rem μCi^{-1} for ^{90}Sr Hypothetical annual ^{90}Sr average is 20 pCi L^{-1} Calculated dose from ^{90}Sr = 20 pCi L^{-1} * 0.13 rem μCi^{-1} * 0.73 mrem μCi L rem^{-1} pCi^{-1} = 1.9 mrem
4	Isotopic ratio is not a reliable indicator of origin in groundwater. Therefore, it is not possible at this time to evaluate whether there is a LANL contribution in tap water samples by our methodology.
5	Sum the doses from all radionuclides above regional concentrations to calculate the LANL contribution to the total water ingestion dose.
6	Sum the food product and water ingestion doses to calculate the total annual ingestion dose.

Calculating off-site MEI dose, continued

Dose from exposure to radionuclides in soils

To calculate the dose from exposure to radionuclides in soils, perform the following steps:

Step	Action
1	Obtain soil analysis data from ESH-20 and include the original data in the records file. **Note:** Soils are collected by ESH-20 in the vicinity and in regional locations and analyzed for radionuclides.
2	Determine the mean and variance of the data from Los Alamos and White Rock locations. Do not use locations on LANL property that are not representative of public areas.
3	Determine net soil concentrations for Los Alamos/White Rock for each radionuclide by subtracting the background soil concentrations from the mean concentrations.
4	Determine the 1*s* of the net by taking the square root of the sum of the variances of the gross (Los Alamos/White Rock) and the background.
5	If the result is significant, perform RESRAD runs. Include direct exposure to, inhalation of, and ingestion of contaminated soil pathways, as appropriate. Check the table in past ESRs for values that have been used in past RESRAD calculations. Do not include plant or drinking water ingestion pathways, as they are included elsewhere. Document the choice of input parameters. Perform runs for the net mean and 1*s* (of the net mean) value for each radionuclide. The dose to be reported is listed as **"0Maximum TDOSE (t): [actual dose result] mrem/yr"** in the RESRAD results printout.
6	Report both the mean and the 1*s* dose to show the uncertainty in the soils exposure dose.

Combine LANSCE and non-LANSCE contributions

Sum the significant contributions to the off-site MEI dose, calculated from: AIRNET; the GENII or CAP88 runs; the TA-18 contribution; the food and water ingestion dose; and the soil exposure dose.

Report this value in the ESR as the mean dose to the off-site MEI.

One standard deviation of this mean may be calculated as the square root of the summed variance from each of the dose contributors. Unfortunately, we have no way of calculating the variance for the LANSCE or TA-18 contributions.

Calculating the On-site MEI dose

Location of on-site MEI

Experience and enhanced environmental monitoring during the past few years have shown that facilities that emit direct penetrating radiation are generally the source of maximum potential exposure to a member of the public temporarily on DOE/LANL property. For several years, the largest contributor to the on-site MEI was determined to be the Criticality Facility at TA-18. The hypothetical maximum annual dose from that facility was presumed to be to an individual who jogged along Pajarito Road, passing TA-18 twice each working day. An extensive, LANL-wide reevaluation of potential direct penetrating radiation sources indicated that the calibration facility (TA-3-130) was another potential source of significant exposure. Environmental monitoring was initiated at the fence line to this facility in the first quarter of 2000 and continued until the facility was moved during 2001. Since the TA-3-130 facility has moved, it is likely that TA-18 will continue to be the source of exposure to the on-site MEI. The dose evaluator needs to continually check for new facilities or new sources that could change the location of the on-site MEI. The following steps describe how to calculate these doses and the all-pathway components.

Calculation of dose from TA-18

Procedure MAQ-505 describes the method of calculating the dose from TA-18 to a hypothetical maximally exposed individual. It is assumed that this hypothetical individual is an "average" resident of Los Alamos. Therefore, the doses to an average Los Alamos resident from LANSCE, food and water ingestion, air inhalation, soils exposure, and from Lab sources other than TA-18 should be added to the TA-18 dose calculated according to MAQ-505.

Calculate on-site MEI dose

To calculate the total on-site MEI dose, add facility-specific doses to those calculated for an "average" Los Alamos resident.

Calculating average dose to residents of LA and WR

Overview

"Average" doses may be calculated in order to evaluate the doses that members of the local population are likely to have received from all sources and pathways. These doses are calculated for "average" residents of Los Alamos and White Rock. The dose calculation is based on AIRNET measured air concentrations (which includes all Lab contributors except LANSCE and TA-18) and incorporates the dose contribution from LANSCE and TA-18 by performing GENII or CAP88 runs based on reported or calculated emissions from those facilities. Water ingestion doses are added to these if appropriate, as described below.

Location of "average" LA and WR resident

The source terms for LANSCE stack and diffuse sources (see Step 1 in the chapter *Calculating Off-site MEI Dose*) are used to model LANSCE contributions to locations in Los Alamos and White Rock considered to be "average" locations. These are assumed to be 5,000 m WNW (sector 6) and 6,800 m SE (sector 15) from the LANSCE sources. If you assume different locations for the "average" individuals, justify and document your assumptions. Use the meteorological data files created for the LANSCE GENII runs for the Off-site MEI.

Steps to calculate on-site MEI dose

To calculate the average dose to residents of Los Alamos and White Rock, perform the following steps:

Step	Action
Model LANSCE contribution	
1	Perform a GENII or CAP88 run for each of the LANSCE sources for the "average" individual location in LA and WR for each period.
2	Sum the effective dose equivalent, EDE (rem) from all runs.
3	Multiply the summed EDE by 1000 to give the effective dose from LANSCE operations in mrem to each "average" location.

Steps continued on next page.

Calculating average dose to residents of LA and WR, continued

Step	Action
Model TA-18 contribution	
4	If another individual is responsible for completing the calculation method in MAQ-506, retrieve the calculated ^{41}Ar source term. Otherwise, perform the ^{41}Ar source term calculation in MAQ-506. **Note:** The only potentially significant contributor to doses in Los Alamos and White Rock from TA-18 operations is ^{41}Ar.
5	Perform a GENII or CAP88 run using the ^{41}Ar source term for the receptor location in Los Alamos and White Rock.
Calculate air pathway inhalation doses from AIRNET data	
6	Obtain the AIRNET quarterly isotopic results for Los Alamos (LA) and White Rock (WR) from the current stations for LA and WR listed below. **NOTE**: These lists will change as AIRNET stations are added or deleted. The objective is to include as many stations as possible to get as representative an average as possible for Los Alamos and White Rock. Los Alamos Stations: 4, 5, 6, 7, 8, 9, 10, 12, 60, 61, 62 White Rock Stations: 13, 14, 15, 16, 63
7	Calculate average annual air concentrations for ^{234}U, ^{235}U, ^{238}U, ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{3}H for the LA and WR stations.
8	Follow steps from the chapter *Calculating Off-site MEI dose* to calculate the air pathway inhalation dose to an average member of Los Alamos and White Rock.
9	Sum the following, as appropriate, to obtain the “average” doses to members of Los Alamos and White Rock: • AIRNET calculated inhalation doses for LA and WR • Doses modeled by GENII for LANSCE and TA-18 contributions • Food and Water ingestion doses • Soils Exposure dose **NOTE:** Los Alamos and White Rock are considered to utilize the same food and water sources and, in general, have the same food and water ingestion doses. However, if a well is giving a dose and it can be shown that it serves either White Rock or Los Alamos but not the other, then it would be appropriate to report the dose only for the city served.

Calculating dose from ingestion

Overview

Foodstuffs that can be grown or gathered locally are sampled and analyzed from numerous locations in northern New Mexico. These foodstuffs data allow the calculation of food ingestion doses at a number of sites. The doses are calculated on the basis of measured foodstuffs; no modeling is performed. Where appropriate, certain foodstuffs ingestion doses are added to hypothetical receptors described above. These are described for each receptor as appropriate in the preceding chapters.

Obtaining annual consumption rates

Annual consumption rates for average and maximum individuals are listed in Table 3-1 (p. 49) of the 1996 Annual Environmental Surveillance Report or are available from USNRC Regulatory Guide 1.109, Revision 1, Oct. 1977, or the EPA Exposure Factors Handbook. Alternatively, results of local surveys on food consumption may be used if they are available. The consumption rates used must be documented in the dose calculation spreadsheets and included in the ESR.

Steps to calculate doses from food

To calculate doses from food ingestion, perform the following steps:

Step	Action
1	Obtain foodstuffs data for Los Alamos and background locations from ESH-20.
2	For each foodstuff type (e.g., squash, peaches, tomatoes, etc.), convert the dry concentration (at each location) provided by ESH-20 to wet concentration based on the dry/wet concentration ratio provided either with the data or by contacting ESH-20 (for all radionuclides except tritium). **Note:** ESH-20 provides uranium data as total uranium.
3	Multiply the U concentration by the isotope-specific activities of natural uranium to calculate specific activities of uranium isotopes.
4	Multiply the uranium isotopic dry concentrations by the Dry/Wet ratio to calculate the wet concentrations. **Note:** Wet concentrations should be in units of pCi/g.
5	For tritium (HTO), ensure that the activity concentration is reported in, or converted to, pCi per mL of tissue water before performing the calculation of wet concentration.

Steps continued on next page.

Calculating dose from ingestion, continued

Step	Action
6	Multiply the tritium concentration (in pCi mL^{-1} of tissue water) by the quantity (1-dry/wet ratio) to obtain the wet concentrations for each vegetable and fruit at each location and background.
7	Average the wet concentration and subtract background to determine a net wet concentration for each radionuclide at each location group for fruits and vegetables (hereafter referred to as produce). **Note:** Generally, produce data are divided into location groups such as off-site regional, off-site perimeter, White Rock/Pajarito Acres, Pueblo of San Ildefonso, and on-site stations.
8	Compute one standard deviation (1*s*) of the net concentrations at each location group according to the following formula: $$C_{Ns} = [(C_{Ws})^2 + (C_{Bs})^2]^{1/2}$$ where: C_{Ns} = standard deviation of the net concentration C_{Ws} = standard deviation of the wet concentration C_{Bs} = standard deviation of the background concentration **Note:** The calculated C_{Ns} values must be carried through all subsequent steps to report 1*s* of the calculated dose at each location group.
9	Multiply the net mean activity and background activity concentrations and their 1*s* values (pCi/g or pCi/ml) by the dose conversion factor (rem/pCi) from the DOE publication "Internal Dose Conversion Factors for Calculation of Dose to the Public" (DOE 1988). **Note:** This gives the dose (rem/g or rem/mL) per unit of produce ingested for each radionuclide for each location group.
10	Calculate the dose from consuming "unit" quantity for each food type.
11	If ingestion of a food type could cause a significant dose, calculate the dose from ingesting an annual "average" ingestion quantity of that food type.

Steps continued on next page.

Calculating dose from ingestion, continued

Step	Action
12	For the ESR, report the CEDE (mrem) and associated 1*s* value for ingestion of unit quantities of produce from each location. **Note:** These calculations provide the CEDE for the annual intake of fruits and vegetables for each location group.

Other ingestion doses

Doses for consumption of piñon nuts, honey, steer, deer, elk, fish, milk, eggs, and tea follow similar steps as above for produce. Sample spreadsheets that were used to calculate doses for the 2000 ESR can be viewed (and copied) electronically from the Ingestion Doses subdirectory in the ESR Dose Calculations directory on the Cleanair Projects drive.

Reporting ingestion doses

Report all doses calculated for all sites in one table. This allows any potential receptor to examine the data from nearest her/his location. Additionally, the dose to Los Alamos/White Rock residents from ingesting food grown or gathered locally can be calculated by summing the doses for all food products collected/analyzed from the Los Alamos/White Rock area.

Calculating special scenario doses

Overview

Laboratory operations have resulted in contamination of water, soil, and sediments, generally in canyon bottoms. Some of these areas are publicly accessible. Visitors of these areas can incur doses by several pathways: 1) inhalation of radioactive materials exposed by wind or water erosion and suspended in air; 2) ingestion of contaminated soil, sediments, water, or food products grown in contaminated soils or with contaminated water; and 3) direct radiation exposure to gamma emitters in soil, sediment, or water. As contaminated areas are identified, an evaluation may be needed to assess the significance of potential public exposures. These calculations cannot be easily proceduralized because of the wide variability in source configurations and exposure scenarios.

Realistic scenarios

In general, according to DOE orders and guidance, we should develop as realistic scenarios and doses as possible. To develop realistic exposure estimates, modeling may be the best choice. Computer models such as RESRAD or GENII have provisions to perform this type of modeling. However, the results of these models are directly dependent on the exposure parameters and scenario that are input. Reliance on default parameters may provide very conservative results. If modeling is used, it will be necessary to assess which potential exposure scenarios are important and realistic. Alternatives to modeling that should be considered are: make direct measurements with appropriate field instruments and then calculate a dose based on those measurements assuming a certain occupancy; calculate dose rates in an area based on soil sampling results and then assess potential exposures based on an assumed occupancy.

When to perform special scenario dose calculations

These dose calculations need not be performed each year. Rather, they are special case evaluations that will be performed as the need arises. Generally, the contamination in these areas is reasonably static and a calculation should remain valid until the presumed exposure scenario changes or until a new or changed contamination source is identified.

Reporting results

The results of the dose calculation may be reported in the ESR whether or not the exposures are significant. If a potentially significant dose is discovered, a further evaluation should be performed to assess contributions from other Lab sources.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted as records to the records coordinator **within 4 weeks** of generation:

- Spreadsheet printouts for ingestion doses
- Printouts of output from model runs in RESRAD
- Printouts of output from model runs in GENII or CAP88
- Documentation of direct radiation monitoring or calculations provided to dose modeler from appropriate sites